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AUTHOR	Haveman, Robert; Wolfe, Barbara
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ABSTRACT

The human capital and growth accounting approaches to measuring the benefits of education both have serious weaknesses. Like other goods and services, educational services have effects on the economic well-being of individuals and families. Because the economic well-being effects of education include private marketed and non-marketed impacts as well as external or public impacts, estimates of the aggregate value of educational services must encompass all of these. To obtain a true understanding of the effects of education on productivity, various non-marketed, private returns must be considered, including the health and fertility effects of education, effects on the value of home time of mothers, effects on criminal behavior, and effects deriving from the impact of education on the earnings distribution. A review of the existing literature on the effects of education in these areas supports the hypothesis that the provision of education services is likely to have a larger impact on economic well-being than is estimated by studies based upon the direct returns or growth accounting frameworks. Therefore, researchers must develop means to measure the full willingness to pay for educational services. (This study is one in a series on the relationship between education and productivity.) (MN)

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Education, Productivity, and Well-being: On Defining and Measuring the Economic Characteristics of Schooling

Robert Haveman and Barbara Wolfe*

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"Of late economists have been spending considerable time attempting to assess the economic contribution of education." So William Bowen begins his 1964 volume of essays on Economic Aspects of Education. Now, nearly two decades and hundreds of studies later, the statement is no less true.

This paper is in the same vein as Bowen's, in that it struggles with both the definition and the measurement of the economic effects of schooling. However, because of the extensive theoretical and empirical research on this issue during the two-decade lapse between Bowen's paper and this one, our discussion is both broader and, in some sense, less concrete than his. A more precise definition of the meaning of economic well-being, a more comprehensive understanding of the complex channels by which schooling alters human behavior (and, hence, well-being and productivity), a far more extensive empirical literature on the behavioral effects of schooling all contribute to the more extended view of education and economic performance reflected in this paper.

Section I is a discussion of education and economic productivity. There, we compare the standard measures of productivity to the ideal measure of productivity that would be employed if more extensive and complete information and data were available. The standard measures are

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*University of Wisconsin-Madison. The assistance of George Parsons is acknowledged.

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partial and, at best, serve as proxies for the ideal productivity measure. The standard measures of the economic effects of schooling are closely related to the familiar productivity measures—the effects of education which are typically estimated are those embodied in the standard productivity measures. Hence, standard measures of the economic effects of education are "partial," in the same way that the familiar productivity measures are partial. In this section, we state our intent to focus on the full contribution of education or schooling to the output or productivity of the economy. Hence, our emphasis on "economic well-being."

In Section II, we briefly review the human capital--or returns-to-education--and the growth accounting approaches to measuring the benefits of education.[1] These are the two primary approaches to this question and, as we will see, they have serious weaknesses. Section III is a brief statement of the welfare economics notion of "benefits." This concept is based on the willingness of individuals to pay for the effects of an activity--either positive or negative effects--and is the monetary equivalent of the "compensating variation" concept of welfare economics. The willingness to pay concept is applicable to the private goods aspects of schooling, as well as to the external (or public goods) components of the benefits from schooling.

Section IV is an effort to distinguish the numerous ways in which the effects of schooling can generate willingness to pay. Channels of impact are distinguished which are far beyond those perceived when Bowen wrote. They include health effects, fertility effects, income distributional effects, home time effects, and technology diffusion effects. Any

full discussion of how schooling affects economic well-being must consider all of these channels of impact.

While we now know a good deal about the private returns to education reflected in earnings differences, less is known about these other channels by which education affects economic well-being. In Section V, we review the evidence which has accumulated in recent years on some of the benefits of schooling not reflected in monetary private returns. In particular, we focus on the health and fertility effects of education, effects on the value of the home time of mothers, effects on criminal behavior, and effects deriving from the impact of education on the earnings distribution. Assessing the impact of education on economic well-being by focusing on only those private returns reflected in earnings differences neglects most of these other contributions, a number of which appear to be quantitatively large.

Finally, in Section VI, we suggest some policy implications which derive from our discussion, and describe a research strategy by which some of these private and non-private, non-earnings related contributions of schooling to economic well-being might be measured.

I. Education and Productivity--Full and Partial Measures

"Productivity" can be defined as the total output in an economy divided by the total inputs which contribute to producing that output. As such, it is among the most comprehensive indicator of the performance the economy. In a very real sense, a productivity ratio is a benefit-cost ratio.

If data and information were complete, statisticians would calculate productivity as a ratio of the total economic benefits generated by the

economy divided by the value of resources which entered into that production. An increase in productivity, then, would be an increase in benefits holding inputs constant, a decrease in costs holding output constant, or a simultaneous increase in benefits and a decrease in costs. And any phenomena--such as education, new technology, or weather--which increased the numerator of the ratio, decreased the denominator, or did both would be said to increase productivity, or to contribute to the growth in productivity.

In fact, data and information are not complete. As a result, statisticians have formulated a variety of surrogates for true productivity. Consider the most common (and official) measure, labor productivity. Instead of measuring the value of all of the outputs of the economy, the labor productivity index includes in the numerator only the outputs recorded in the nation's national income and product account. Indeed, in some measures only the output of the private non-farm business sector are included. The contributions of the economy to non-marketed benefits--for example, reductions in accidents and illnesses, increases in leisure, improvements in product quality, reductions in travel or waiting time--are all neglected in the standard productivity measures. Similarly, the labor productivity index includes only one input, labor, in the denominator. The contributions of capital, natural resources, or other non-labor inputs to the economy are neglected.

A number of more extensive productivity measures than this simple, single-factor measure have been developed in recent years. The primary improvement is in including more factor inputs than labor in the denominator of the productivity index. These are referred to as full-factor

productivity measures, and are represented primarily in work by Denison (1962, 1967, 1979), Kendrick (1961, 1977), and Christensen and Jorgenson (1973, 1980). Full factor productivity measures are still partial. They still accept as the output numerator only those effects recorded in the national income accounts, and in fact still neglect some real inputs to the economy.

The most common measures of the economic effects of education--or using a more limited notion, schooling--are the human capital (or direct returns) and growth accounting measures. These measures--which will be critiqued in detail in Section II--have problems which are very similar to those of the standard productivity measures. They measure only a portion of the full benefits of schooling, and capture only a portion of the full costs of providing education services. In fact, some of the "rate of return" measures of the economic effects of education suffer from almost the same limitation as the standard productivity measures--the returns are measured as only those effects which are recorded in the nation's income and product accounts.

Both standard productivity measures and the commonly used measures of the economic effects of schooling are proxies for their more comprehensive counterparts. Because both are partial indicators of the phenomena which they are designed to reflect, the answers which they provide may be misleading, indeed wrong. For example, true productivity--the ratio of the full economic outputs of the economy divided by all productive inputs to the economy--might well be rising at the same time that the standard, partial measures are suggesting that productivity is falling. This might be particularly true if leisure were increasing.

The discussion of the relationship of schooling to productivity in this study takes a comprehensive view of the measuring of productivity. The output measure which we will use is one which reflects the total output of the economy valued at what individuals are willing to pay for that output. It goes well beyond the Gross National Product measure of output, or any of the other output measures used in the standard productivity indexes. Indeed, our output measure captures the contribution of the economy to what we call "economic well-being." Our analysis of the contribution of education or schooling to productivity, then, is in terms of its contribution to this full measure of economic well-being. In Section III, we will make this output concept more precise; prior to that, however, we will describe how estimates of the economic effects of schooling have been based on partial measures of output in the standard studies.

II. Measuring the Economic Effects of Schooling

Section I has emphasized that economic well-being in a society is more than aggregate personal income or Gross National Product--that the full productivity of an economy is different than the official labor productivity index. To be sure, the money values reflected in GNP or private sector output are components of well-being--indeed, they are probably the major components. And, for many purposes, GNP may serve as a good proxy for economic well-being; and the standard productivity indices for true economic productivity. Moreover, those variables which ultimately determine the aggregate level of economic well-being--education, health status, environmental amenities, the productive capital stock, the housing stock, the level of public sector infrastructure--may also be

closely related to aggregate levels of gross income and product. It is this judgment which underlies the primary efforts to measure the economic effects of schooling. Indeed, both the "direct returns" approach and the growth accounting approach reflect the view that the economic well-being effects of education are captured by the impact of education on measured income and product.

The Direct Returns Approach

The pioneering work on human capital is that by Mincer (1958, 1970) and Becker (1964). In Mincer's formulation, the logarithm of earnings is a linear function of the years of schooling (S) and a quadratic function of an experience variable (j), thought of as post-school investments in human capital and defined as age (A) less (S + 5).

$$\log Y = a_0 + a_1 S + a_2 j + a_3 j^2 + \varepsilon \qquad (1)$$

This basic formulation has several characteristics relevant to its use in estimating the direct economic returns to education:

1. It assumes implicitly that all private direct returns to education are reflected in measured earnings of individual recipients of educational services; no non-labor market effects (e.g., non-monetary differences in the quality of jobs) are admitted, nor are the consumption benefits of education.
2. It assumes that, in the absence of post-school training, the age earnings profile is flat and the present value of individual earnings is constant across individuals, regardless of the length of schooling.

3. It posits that the rate of return to post-school training is constant irrespective of the age at which the training is obtained.

4. It assumes that the individual maximizes lifetime earnings, ignoring hours of work and hence hours of leisure.

The first of these assumptions is clearly not true, as we will argue later in this paper. And, as Blinder (1976) has emphasized, there are good empirical and theoretical reasons for doubting the remaining assumptions. If the first assumption does not hold, and if those effects of education on economic well-being which are not reflected in labor earnings are on balance positive, the estimates of the returns to education based on this direct returns framework are lower bound estimates. The implication of the inaccuracy of asssumptions 2.-4. is that empirical estimates of the benefits of education are likely to be unreliable; overestimates caused by some of the assumptions are offset by underestimates due to other assumptions in some unknown way.

In addition to these modelling issues, human capital based empirical estimates on the direct earnings effects of education are encumbered by serious data and specification problems. The concept of human capital--or, indeed, education--is an unobservable variable, and as a result estimation of its impacts confronts problems of censored data and self-selection. The contribution of education services to earnings differences cannot easily be disentangled from differences in abilities, tastes, ambition, or "connections." Estimates of returns (or earnings inequality) impacts based on life cycle income concepts are different from--and inconsistent with--estimates based on a shorter accounting

period. The effect of labor demand differences on earnings has not been effectively or reliably incorporated into earnings functions. Indeed, the definition of human capital used in the various studies is inconsistent--the concepts of ability, schooling, skills, and the empirical counterparts of each are complex and have not been clearly thought out in the literature. The complex structure by which truly exogenous factors can be identified and their effects on outcomes kept separate from that of other factors has not been clearly set forth. For example, schooling may change individual's learning capabilities as well as one's earnings (Welch, 1970). And, finally, the accumulation of human capital, while an aspect of lifetime utility maximizing choice in a framework of earning, consuming, and leisure-taking, has been evaluated in a context in which life cycle variation in work time has not been well accounted for.

The Growth Accounting Approach

The growth accounting framework is a national income account based technique for evaluating the contribution of various factors to observed growth in output. Estimates of the contributions of education services to income growth have also been derived using this technique, and compared to those obtained from the direct returns approach. The application of the growth accounting approach has been pursued most forcefully by Kendrick (1966) and Denison (1962, 1967, 1979) since the early 1960's. In these analyses, education is one of these factors contributing to output growth.

In the growth accounting framework, factor inputs (and various elements which determine their productivity) are the determinants of national output (measured as national income or net national product valued at factor cost). The determinants of output demand or input supply are not explicitly considered. In the analysis, the determinants of output combine multiplicatively--as a result, their exponential rates of growth combine additively. For example, in the case of labor, the following components comprise the total input: number of persons employed; average hours (adjusted by various factors); age-sex composition; education; and unallocated. The contribution of labor to the growth rate of productivity (National Income Per Person Employed--NIPPE) is obtained by subtracting the contribution of the number of persons employed from the remainder of labor's contribution. In the 1948-73 period, for example, the contribution of labor to the average annual growth rate of output was 1.42 percentage points, of which education was credited with .41 percentage points. Of the rate of growth of productivity of 1.52 percentage points per year during this period, education was again credited with .41 percentage points per year.

Throughout the various phases of Denison's work, the contribution of education to output growth has always been positive, and has accounted for about 15-25 percent of economic growth. As Table 1 indicates, Denison has estimated that the contribution of education to productivity growth has increased over time; the contribution in 1973-76 less that in 1948-69 was .4 percentage points; that for 1969-73 less that in 1948-69 was .2 percentage points. Kendrick's analysis, also based on a growth accounting framework, suggests a similar pattern for education. The

Table 1

Change in the Effect of Various Factors on Productivity Growth: Contribution in Percentage Points of Various Factors to the Growth Rate of Productivity in Recent Years Minus the Contribution in Past Years

Factor/Author	Denison[1]	Denison[2]	Kendrick[3]
Cyclical effects Weather, work stoppages %	0.2	-0.4	-0.6
Shifts from manufacturing to services	—	—	-0.1
Shift from farm to nonfarm Shift out of self-employment %	-0.4	-0.3	-0.1
Changes in hours worked	-0.3	-0.1	—
Labor force composition	-0.1	-0.3	-0.3
Education	0.4	0.2	0.2
Health and vitality	—	—	0
Nonresidential structure and equipment	-0.1	-0.1	—
Inventories	-0.1	0	—
Economies of scale	-0.2	0	-0.2
Land	0	-0.1	-0.1
Pollution abatement Other regulation %	-0.4	-0.2	—
Government services	—	—	-0.1
Diffusion of knowledge	—	—	-0.15
Residual factors (Advances in Knowledge)	-2.1	0.2	0.2
Total change explained	-3.1	-1.0[4]	-1.5

[1]Compares nonresidential business income per employed person in 1973-76 versus 1948-69.

[2]Compares nonresidential business income per employed person in 1969-73 versus 1948-69.

[3]Compares private sector output per total factor input in 1976-76 versus 1948-66.

[4]The sum of the component parts does not equal the total because of rounding errors.

results of Denison's analysis, however, have been puzzling in recent years. The category of "residual factors" composed of advances in knowledge and components not classified elsewhere (and in many cases not even identified) contributed a change of -2.1 percentage points per year to productivity growth in 1973-76 relative to 1948-69, as opposed to a change of .2 percentage points per year in 1969-73 relative to 1948-69. As Denison stated, "It is possible, perhaps even probable, that everything went wrong at once [during the 1973-76 period] among the determinants that affect the residual series." (p. 143).

While Denison's results suggest a large and growing contribution of education to output growth, the unexplained behavior of the residual casts doubts on the reliability of this as well as the remainder of the estimates. As Stone (1980) has commented regarding the role of the residual: "This is a counsel of despair. The presence of a residual in any set of accounts is pernicious because it does away with the only constraint to which the data are subject." (p. 1540). Abramovitz (1956) called it "a measure of our ignorance." (p. 11).

The growth accounting framework, however, has still other weaknesses as they pertain to the contribution of education to either output or productivity growth. First, education refers only to changes in the amount of formal education received by members of the labor force. As a result, it does not account for improvements in the quality of a year's worth of schooling or increases in a variety of educational services other than formal education. This criticism is not dissimilar to that levied at the estimates of the direct return to education provided by studies employing the human capital framework. The second criticism is also similar to one

discussed in connection with the human capital framework, namely, the only output which is attributed to education is that recorded in the national income accounts--its effects on other components of economic welfare (for example, the consumption value of education) is neglected. Third, Denison's estimates of the contribution of education to measured output are plagued by his inability to adjust observed earnings differences associated with education for the loss of experience attributable to education and the differences in abilities and motivation of those who in fact acquire more education. As a result, Denison assumes that three-fifths of the observed education-income relationship is attributable to education. Finally, several of the indirect effects of education--for example, its impact in increasing the labor force participation rate--are not accounted for.

Other Approaches

In addition to the human capital and growth accounting approaches, there have been other attempts to evaluate education's impact on income. These are (1) the educational planning approach and, (2) the "supply and demand" approach.

Those adopting the educational planning approach attempt to derive the demands for labor of varying education levels through estimation of production functions identifying labor of various schooling levels. The estimated substitution elasticities among labor categories distinguished by education levels is relevant to estimates of the impact of increases in education at various levels on relative wages and incomes. The estimates of this elasticity between higher and lower education individuals

vary widely, but nearly all are in excess of unity. The implications of this on the expected marginal rate of return on, say, higher education, are significant, implying that factors other than relative supplies and demands account for much of the earnings differential among workers of various education levels.

As distinguished from the supply-oriented human capital and demand-oriented educational planning schools, Tinbergen's (1975) analysis of inequality of labor incomes rests on his view that the observed level of income inequality is the outcome of a supply-demand race involving educated labor. In this framework, it is changes in technology that expand the demand for labor possessing high skill and education levels. If such changes in technology shift relative labor demands toward highly educated labor and away from less educated labor--and if there is no change in the educational composition of the labor force and low elasticities of substitution among workers of various levels--the equilibrium wage rate of highly educated labor will increase relative to that for less educated labor, and inequality between the two will increase. Hence, in his words, "reduction of inequality is possible only if the expansion of education overtakes the expansion required by technological development."

While Tinbergen's analysis leaves as many questions unanswered as answered, it does appropriately cast discussions of the impact of educational services into an appropriate general equilibrium, supply-demand framework. And it does cast the question of the impact of changes in the quantity of education or changes in the education system into an appropriate income determination-income distribution process.

III. Education Services and Economic Welfare

Neither of the two standard approaches to measuring the benefits of educational services--the direct returns and the growth accounting approaches--capture the full value of educational services. In addition to other problems mentioned in part I, this is the fundamental criticism of both approaches. In this section, we inquire into the meaning of the economic well-being benefits of goods and services consumed by individuals, irrespective of the nature of the goods or services. First, however, a brief description of the nature of educational services.

Educational Services as Public and Private Goods

In some of its guises, educational services are privately demanded. Higher education services, for example, are not mandated; the amount of them consumed is at the discretion of individual consumers. The incentives for individual choice, however, are often altered by collective action. For example, higher education services at state institutions are offered at prices (tuitions) which are below marginal costs. Similarly, student assistance (whether public or privately offered) or subsidized loan arrangements seek to induce a greater demand for higher education services than would otherwise be observed.

Individual demands, apart from the special inducements, reflect the private gains which recipients of the services are likely to experience. These private gains can be of a variety of types; here we will distinguish but two. First, there are the private gains which are reflected in market incomes and gross national product. These are the

productivity increases due to education which are manifest in increases in the output of goods and services. A second form of private gain is a direct increase in utility attributable to education. For example, individuals may enjoy the process of being educated. In addition to these private effects, there are more widely dispersed--or "public" effects--of higher education services. These effects are not fully reflected in private demands. As a result, the quantity of higher education services privately demanded will fall short of demands which reflect both private and public effects. The extent to which full private and public benefits of education are not reflected in market demands is crucial in determining if, at the margin, the economic well-being benefits of education exceed or fall short of the economic costs of producing them.

The provision of education services at lower levels is not dominated by private choices. In the case of elementary and secondary education, for example, attendance is mandatory. For those students in public institutions--the substantial majority--the volume of education services provided is determined collectively. Only for the small (but growing) proportion of children in private schools is the volume of education services a matter of private choice.[2] However, even in the case of publicly provided education, the education services provided are not pure public goods. As in the case of higher education, much of the benefit of educational services is privately expropriated;[3] in this case as well, however, spill-over benefits accrue to the community at large in the form of public goods.

For all major forms of education services, then, private demands and provision are mixed in some fashion with collective provision and collec-

tive effects. In the higher education sector, collective provision plays a small role relative to that in sectors providing lower levels of education. However, irrespective of the level of education services provided, the output stream yields benefits in the form of both private and public goods, although in varying combinations. As a consequence, evaluation of the full benefits of education must encompass benefits reflected in earnings increments, private benefits represented by direct utility changes, and public benefits of educational services.

The Concept of Economic Benefits

Contemporary welfare economics provides the conceptual underpinnings for defining the contribution of service flows--whether from public or private goods--to economic well-being. As depicted in formal analyses, both forms of service flows enter individual utility functions, and the utility impacts of each can be represented by marginal benefit functions. Such relationships, also known as marginal willingness to pay functions, display for any quantity of the good consumed the value of other goods and services consumed by the individual which he or she would have to receive in order to be compensated for the loss of one unit of the good in question.[4] The area under the curve from zero units to the amount of the good or service consumed is the total value of that amount of the good or service consumed to the individual--that commodity's contribution to the individual's well-being. This total value would be consumers' surplus if the specified quantity was secured at zero price. It equals the full contribution of the good or service to the individual's economic

well-being. At a positive price, the total willingness to pay equals the amount actually paid plus the amount the individual would be willing to pay rather than go without the consumption of the good (the area under the curve from zero units to the amount of the good or service consumed but above the price).[5]

This willingness to pay concept of the contribution of various forms of consumption to total individual well-being applies to both private and public goods. The measurement of this willingness to pay value is quite different for the two types of good, however. For pure private goods--those which pass through a competitive market and for which a price can be observed--measurement of the economic benefits of consuming any traded amount requires estimation of a demand curve and the measurement of the appropriate areas under it.

For pure public goods, however, measurement of the contribution which consumption of the good or service makes to economic well-being is substantially more difficult. In this case, price-quantity combinations--from which willingness to pay functions are constructed--are rarely observed. And, given the public good nature of these goods, if these combinations were observed we would expect them to underestimate the true willingness to pay associated with each quantity. While a number of conceptually correct approaches have been proposed and evaluated--including direct survey questions regarding willingness to pay and the inferring of values from price-quantity relationships of commodities whose consumption is complementary with that of the public good in question--none is without serious problems. And, all of the empirical research which has sought to estimate the economic well-being benefits of public goods has confronted serious data and estimation problems.[6] Nevertheless, a full

evaluation of the contribution of any good or service to economic well-being must be based on the estimation of this total willingness to pay--the sum of the amount actually paid and consumers surplus--of all of the citizens benefiting from consumption of the good or service.[7] To the extent that provision of any identifiable service yields well-being effects of a variety of types, the willingness of citizens to pay for these benefits must be measured and aggregated over types.

This conclusion is particularly relevant in the case of educational services. They, as much as any other good or service, convey a wide variety of effects--some are of a public good character, others are private goods, either in the form of monetary returns or direct consumption--with economic well-being implications. It is to this variety of effects on well-being that we now turn, in an effort to distinguish the primary channels by which educational services create or reduce economic well-being and their private and public good character.

IV. The Effects of Education on Economic Well-Being: The Channels of Impact

Two primary points were emphasized in section II. First, educational services, like other goods and services, have effects on the economic well-being of individuals and families, which effects are valued by means of the willingness to pay concept of welfare economics. Second, the economic well-being effects of education services include private marketed and non-marketed impacts as well as external or public impacts; estimates of the aggregate value of education services must encompass all of these. In this section, we will attempt to identify the major channels of impact by which education services affect economic well-being. This exercise

will indicate which of these impacts are captured by analyses based on the direct monetary returns and (to a more limited extent) the growth accounting frameworks. This approach, then, grows out of the benefit-cost analysis framework of welfare economics. Its emphasis is on the total return from educational services, and not on the marginal effect of a dose of educational services.

A. Human Capital Based Effects Of Education

1. Earnings Differentials

From the perspective of the human capital framework, the principal effect of educational services is the increased productivity of the direct recipients of these services. Given perfect labor markets, labor services will be sold at their market price and the productivity increase generated by education will be reflected in the wage rates and earned income of the recipients of educational services. Hence, wage differentials among education levels reflect the productivity returns to education services. These returns are captured in standard human capital based estimates of education benefits; they are private returns, and under certain labor market conditions, they are also social returns. They are shown in Figure 1.

2. Labor-Leisure Choices

In addition to earnings increases, however, education services may generate other productivity-related impacts which also convey economic well-being. For example, increases in human capital, by enabling workers to command higher wage rates are also likely to induce alterations in

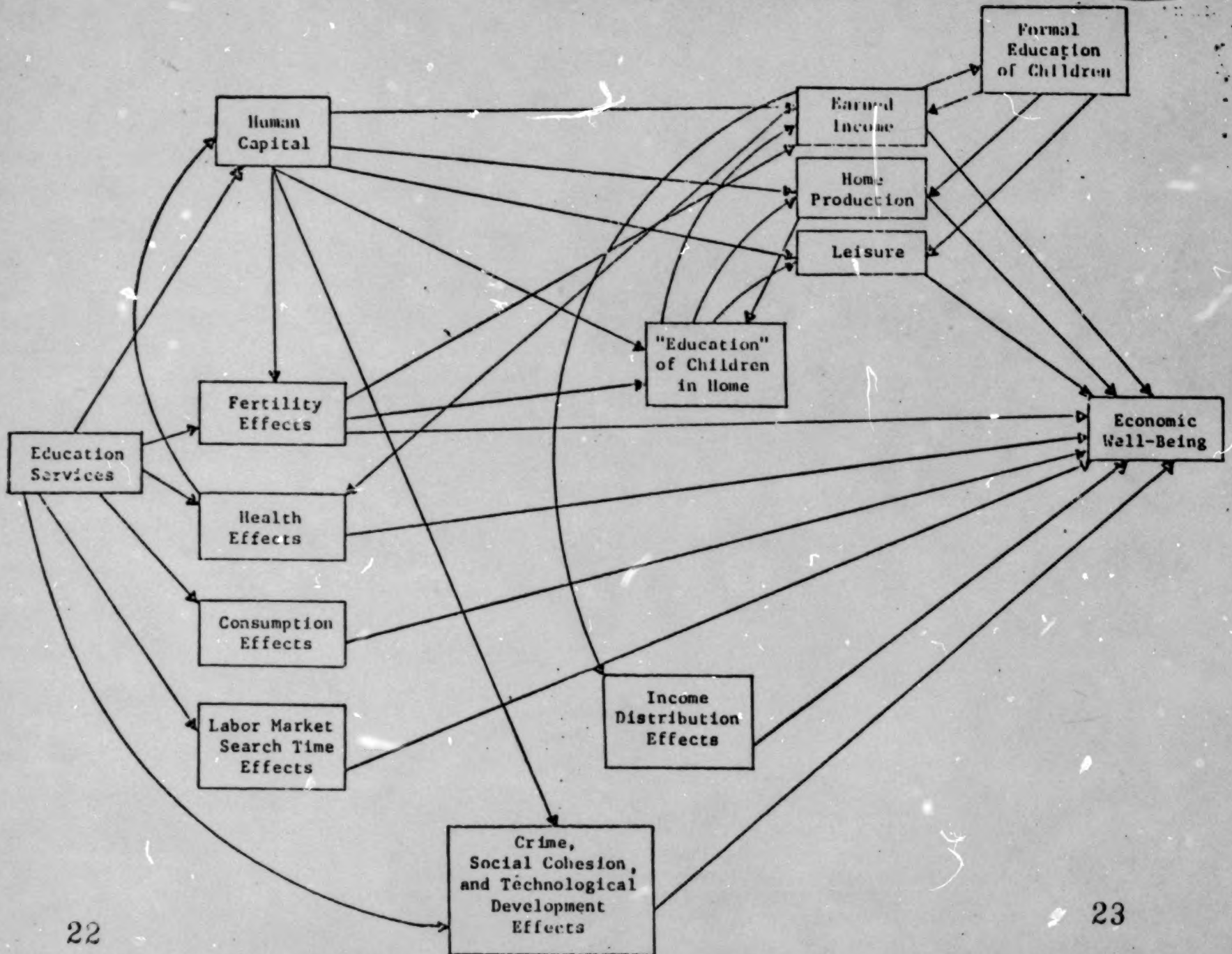
Formal Education of Children
Human Capital
Earned Income
Home Production
Leisure
"Education" of Children in Home
Fertility Effects
Education Services
Economic Well-Being
Health Effects
Consumption Effects
Income Distribution Effects
Labor Market Search Time Effects
Crime, Social Cohesion, and Technological Development Effects

Figure 1

labor-leisure choices. In particular, if leisure is a normal good, additional education is likely to induce an increase in the quantity of leisure chosen--the standard backward-bending portion of the labor supply curve. Individuals are willing to pay for this additional leisure, and it must therefore be credited as a well-being benefit to the education services which induce it. Although earnings may decrease because of this choice--and earnings differentials among education levels as well--economic well-being will tend to increase.[8]

3. Non-Market Productivity Differences

Education may also influence the uses made of an individuals' leisure time. If education increases an individuals' productivity, and hence his/her labor market rewards, these same education services are likely to generate an increase in the value of the activities in which the person engages during leisure hours. This higher value must serve as the basis for the evaluation of leisure time. For example, if these hours are spent in productive activities--e.g., do-it-yourself activities--the increased output in this non-market sector which is attributable to education should also be calculated, and included in the value of leisure time.

The direction of the effect of education services on home production is not necessarily positive, however. For example, education may have the effect of increasing market work activities at the expense of home production activities. This effect has often been cited for females, in which the increase in labor force participation is seen as coming at the cost of reduced home time spent with children, less housework-type activities, and less do-it-yourself activities.

A Digression on the Benefits of Education-Induced Changes in Mothers' Home Time

One likely effect of education is to alter time spent in the labor force and time spent on leisure or home production. For the time spent in the labor force, the benefits of education are measured through earned income increments. However, the other results of changed time allocation are generally not measured. Consider the reduced (or increased) home time spent by mothers with children as a result of an increment in mothers' education. If, as is often speculated,[9] a reduced level of home-based efforts results in lower achievement levels for children, a set of indirect impacts on earnings, home production, and leisure—in this case by the children of the educated parent—must also be measured and valued at the willingness of recipients to pay for them. These indirect effects are also shown in Figure 1. Let us consider this indirect impact of education on mother's home time in somewhat more detail.

In the human capital model, spouses who are not in the labor force bear an opportunity cost in the form of earnings sacrifices. Hence, if education leads to decreases in home time, the reduction in these opportunity costs will be captured as a benefit of education services. Similarly, the impacts of mother's home time in the form of increases in children's earnings are consistent with the human capital model, and should be measured and attributed as benefits of education. For example, if education decreases home time, the reductions in the future earnings of children should be reflected as negative benefits of mother's education.

In addition, there are effects of the home time of mothers which are not reflected in their own or their children's future earnings. One such effect is the value of the non-market work time of wives (mentioned above), the benefits from which offset the opportunity costs of foregone earnings. A second effect is the non-earnings-related benefits to children of mothers' home time--for example, benefits in the form of children's increased future value of home production as a result of increases in mothers' home time. Because both of these latter effects are likely to be positively related to mother's home time, the true net benefits of mother's home time are greater than those reflected in the future earnings of children. Hence, if increased education services provided to women lead to decreases in mother's home time, the effects (benefits) of education services estimated through earnings increases of the recipients of education services (mothers) will overstate the true benefits of the services.

These effects are reflected in the following example:

Marginal Benefits and Costs of Increases in Mother's Home Time

Marginal Benefits	Marginal Costs
Value of Wife's Leisure Time = 25 (including child services)	Earnings Foregone = 25
Increases in Children's Future Earnings = 5 (not included in child services)	
Non-Earnings Benefits of Wife's Home Time Accruing to Children = 2 (not included in child services)	

Assuming that there are benefits to children not included in the couple's own utility function and that the spouse attains equilibrium

when money wages equal the value of her leisure time, this example indicates that a one unit increase in wife's home time (caused by any exogenous change) would yield net benefits of 7. Conversely, should education services, say, lead to increases in wages so that earnings foregone rise to 30, but the value of wife's leisure time does not change, and as a result, mothers' home time is reduced by a unit, the net benefits would be -2. If estimates of the benefits of the education services to mothers were based only on earnings increments of mothers, a value of 30 would be recorded. Hence, if the effect of education is to decrease mother's home time, the increase in economic well-being will be less than that suggested by estimates based only on mother's earnings differentials. Indeed, as the example suggests, the true change in well-being could be negative, although estimates based on direct earnings impacts would yield a positive value of educational services.

For example, Mincer and Polachek (1974) estimate that the per child earnings foregone by wives due to home time varies by education level of mother:

< 12	$ 7,700
12-15	10,700
16+	16,800

Assume that the benefits of the home time of the mother, in the form of increased future earnings of children and other non-earnings benefits accruing to children, are constant over the education distribution at, say, $4000, and not reflected in the mother's utility function. Assume also that both earnings differences and differences in the value of mother's leisure time are taken into account in estimating the benefits

of education.[10] If marginal and average benefits and costs of home time as experienced by the mother are equal in equilibrium, the true net benefits of an increase in home time per child are underestimated by $4000. Conversely, a reduction of home time due to increased education of wives would be associated with both gains and losses, only part of which are measured by direct earnings returns and changes in the value of leisure time. Real economic well-being effects of education will be $4000 less in this example than would be estimated.

The general conclusion that estimates of education benefits based on earnings differences overstate true benefits does not depend on the direction of the effect of wife's home time on the value of children's earnings or non-earnings effects. For example, if increased mother's education increases children's earnings and non-earnings benefits (even in the face of reduced home time) by the amounts stated in the benefit and cost account shown above, the true benefits of education would be 37 (30 of increased earnings plus 7 of increases in children's earnings and non-earnings benefits), and the true costs 25, for net benefits of 12. The estimate of net benefits based only on wife's earnings increases would be 30, which is again an overestimate.

4. The Aggregate Return to Education with Disequilibrium Labor Markets

Estimation of the direct productivity-related returns of education services is based on a particular presumption regarding the operation of the labor market and of the economy. In particular, it is assumed that the economy is a reasonably competitive, neoclassical economy in which price and, in particular, wage adjustments serve to equilibrate markets,

and that such adjustments occur in response to changes in supply and demand.

In recent analyses, a disequilibrium framework has been developed in which wage and price adjustments do not occur in response to supply and demand changes. In this framework, unemployment--rather than wage rates--serves as the equilibrating mechanism. Work by Todaro (1969), Harberger (1971b), Sen (1972), Field (19), and Stiglitz (1974), all of which concerns an economic situation in which substantial unemployment exists, is based on this framework.

The following simple model illustrates this framework and its implications for evaluating the economic well-being effects of education services. Consider a two-sector economy--rural and urban--with a wage differential ($W_u - W_r$) between the two sectors. This differential induces migration. Migration to the higher wage urban sector continues until urban unemployment rises to equate the "expected value" of urban and rural wages. The expected value is equal to the wage rate if hired times the probability of being hired (which equals 1 minus the sectoral unemployment rate).

As a consequence of this process, for example, the hiring of an urban unemployed laborer (say, by the government) causes a reduction in the urban unemployment rate (U). This reduction in urban unemployment increases the expected value of the urban wage. As a result, if migration continues until the rural wage (W_r) equals the expected urban wage [$(1-U)W_u$], the opportunity cost of hiring an unemployed urban worker is W_u (and not zero, as is often concluded). That is, if W_u and W_r are fixed and unemployment is the equilibrating mechanism, $W_r = (1-U)W_u$.

A numerical example will make this last result clear. Assume $U_s = .4$, $U_n = .33$, $W_s = 5$, $W_n = 3$, $V_e = 2$. In this case, the net social benefit of educating one unskilled worker is zero, the net private benefit is 1, and the benefit as measured from observed wage differentials is 2. This conclusion ignores the possibility that educated workers employed in the unskilled labor market may be more productive than unskilled workers in that market. If this were the case, the net social benefit would exceed zero. Positive social benefits could also occur if educated workers in unskilled jobs have a positive effect on the productivity of unskilled workers in these jobs.

However, in the absence of these latter effects, if unemployment exists and if wage rates do not equilibrate, standard estimates of the benefits of education based on observed wage differentials will overstate the true contribution of education to economic well-being.

B. Fertility Effects of Education

While the relationship of education to fertility or child bearing has often been noted, its basis is not well understood. If it is assumed that utility depends upon both consumption and children, reductions in fertility in response to increases in human capital would be expected. The reward to work increases because of education, and simultaneously, the opportunity cost of home time also increases. The incentive is to substitute market income--and the consumption of goods which it affords--for the "consumption" of children with its required home time.

The fertility response to education can also be understood apart from its interaction with the acquisition of human capital. This would be the

case if education serves to directly change individual tastes for children, relative to other forms of consumption. This taste alteration effect of education is difficult to deal with within an economic framework. Yet it seems unreasonable to deny that education, among all public services, is likely to change preferences for styles of life and relative consumption patterns.

The dominant approach used to model the relationship between fertility and women's education is the framework of the "new home economics" developed by Becker (1965), Willis (1973), and others. The model emphasizes the trade-off between the number of children (quantity) and the quality of children in producing child 'services,' which services are hypothesized to enter the parental utility function. Parental utility also depends on the parent's own consumption of goods and services. Parents maximize their utility subject to production functions for child quality and commodities consumed by the parents and a full income constraint that depends on the time of parents, the value of the time of parents, other income sources, and market prices.[11]

Within the new home economics framework, education also plays a role in allowing a family to achieve its desired family size. If the net value of an additional child is negative, the household improves its well-being by lowering the probability of conception. One way to do this is to use contraceptives. However usage involves costs (in terms of expenditures on contraception, psychic costs and/or costs of foregone sexual gratification) so that parents may demand more children than they would desire if contraception were less costly. Education is likely to reduce costs of using contraceptives through several channels: greater

for one not in the labor market (V_e). For a skilled worker, the equilibrium expected wage in the skilled labor market will equal the observed wage in the unskilled market. These two equilibrium conditions are:

$$V_e = (1-U_n)W_n$$

$$W_n = (1-U_s)W_s$$

Assume, now, that an unskilled worker not in the labor market is educated (again at zero direct cost). The social cost of removing this worker from his alternative activity is V_e. With education, he enters the skilled labor market queue, increasing U_s and decreasing $(1-U_s)W_s$. As a result, some unemployed skilled worker will leave the skilled market [as $(1-U_s)W_s < W_n$] and enter the unskilled labor market. As a preferred worker, he will obtain a job. As a result, some unskilled, employed worker will be displaced and enter U_n, decreasing $(1-U_n)W_n$. In the final step, equilibrium will be achieved when some unemployed unskilled worker drops out of the labor market and engages in activities valued at V_e.

In this case, then, the gross social benefits of education are V_e, the social costs of education are V_e, and the net social benefits are $V_e - V_e = 0$. The private benefits, however, are quite different. The gross private benefit to the educated worker is W_n (his expected wage in either labor market). His private costs equal $V_e = (1-U_n)W_n$, and net private benefits equal $(W_n-V_e) > 0$. If (as in standard estimates) the gross benefit of education is taken to be the skilled wage and the cost of education is taken to be the foregone unskilled wage, the net benefit of education is measured as $W_s - W_n$, which exceeds the net private benefit of education.

Consider, first, the case in which there is excess supply in the skilled labor market (U_s), but not in the unskilled market. Assume that the equilibrium in the two markets is such that the expected wage in the skilled market $[(1-U_s)W_s]$ equals the market wage in the unskilled market (W_n). The equilibrium is maintained by skilled workers migrating between the two markets--W_n and W_s are fixed. Educated workers are hired first in the unskilled market, even though education does not increase their productivity in that market.

Consider, now, the impact of educating one unskilled worker, hence adding one person to the stock of skilled workers. That worker will enter the job queue in the skilled market, reducing the expected wage in that market by increasing U_s. Some educated workers will enter the labor market for unskilled labor until U_s falls to restore the equilibrium. Because educated workers are hired before unskilled in the unskilled market, some skilled worker migrating out of the skilled market queue (U_s) will find employment in the unskilled market. This worker will simply replace the unskilled worker who was educated. Now the unskilled market will have an additional skilled person employed in it, but no productivity increase will be experienced. The gross social benefit of the education provided is W_n. Assuming no direct cost of providing the education, the social cost is the removal of the unskilled worker from employment in the unskilled market, also equal to W_n. As a result, the net social benefit of the education provided is $W_n - W_n = 0$.

Now, let us change the model slightly, to allow a job queue in the unskilled market (U_n) as well as in the skilled market. Now, in equilibrium, the expected wage for an unskilled worker will be equal to the value of home production (or underground economy activity or leisure)

receptivity to new ideas, increased awareness of new techniques, and increased efficiency in using any contraceptive.

In Figure 1, two of these linkages between education and fertility are shown--one indirect through human capital accumulation and the other direct, reflecting a change in tastes. Changes in fertility behavior are also shown affecting economic well-being. The existence of this linkage is obvious; estimation of the economic value of changes in completed family size is less straightforward. Yet, to the extent that fertility decisions are voluntary and do occur in the context of individual optimizing choices over a variety of consumption goods, these decisions will have positive economic well-being implications. If changes in standard-good consumption in response to changes in relative prices cause changes in net willingness to pay--consumer surplus--so too do changes in completed family size caused by changes in the relative price of child bearing, contraceptive use, and child rearing.

The economic well-being effects of fertility changes attributable to direct taste changes caused by education are more difficult to define. Irrespective of the magnitude--or of the sign--of the economic well-being effects of education operating through fertility changes, it is clear that neither the human capital model nor the growth accounting framework captures them in any systematic way.[12] Because education induced changes in fertility are likely to generate increases in economic well-being, standard estimates of the benefits of education tend to be biased downward.

C. Health Effects of Education

The provision of education services can also have effects on health and longevity. Such benefits occur through 1) the information effects of education (e.g., awareness concerning the determinants of health status and the potential benefits of prevention and avoidance activities), 2) the effects of education on occupation and location (e.g., higher educated individuals tend to hold jobs which are less dangerous), and 3) the effects of the higher earnings associated with more education on the consumption of health care services. These benefits will be reflected in both the health status of the direct beneficiaries of education services, and that of their children.

In Figure 1, education is seen as directly affecting health status, and as having an effect through the increase in earnings associated with human capital investments. Simultaneously, improved health status is, itself, a form of human capital and will, through this channel, influence earnings.[13] While improved health status will contribute to economic well-being through its effects on earnings, it will directly affect economic well-being by providing non-marketed services--increases in longevity, increases in the quantity and quality of well-time while living, and reductions in health care costs.[14] These contributions to economic well-being are captured in unobserved demand functions for non-marketed goods. While standard estimates measure education-related health effects which are manifest in increases in earnings, the contribution of education services to economic well-being through increases in longevity and well time (outside of work time) and decreases in health care costs are not so captured. To this extent, standard estimates of the benefits of

education services understate their full contribution to economic well-being.

D. Consumption Effects of Education

A classic example of a non-marketed, yet real effect of education, is its value as a consumption good in its own right and its effect on the value of consuming other goods. An important component of the demand for education services, so the argument goes, is the value of these services as consumption goods. Individuals place a positive value on the experiencing of education--it is as if attending lectures is like attending a concert. Moreover, it is further argued that through the gaining of education the future enjoyment of other kinds of meritorious consumption activities--reading, music, art--will be increased, and that these benefits also affect well-being and hence should be attributed to education. To the extent that these effects do exist, they should be attributed to the provision of education services. And to the extent that the sign on them is positive, standard estimates of the benefits of education based on earnings differentials will be understated.[15]

E. Labor Market Search Time Effects of Education

The efficiency with which the labor market functions depends, in large part, on the effectiveness with which available workers with their skills are matched to jobs with their requirements. The process by which these matches are made is often envisioned as a search process in which both available workers and employers engage in a search designed to secure the best match among the available options. This process is a

costly one, and the longer the time lapse between the initiation of search and the securing of a match or the poorer the match which is attained, the more costly is the process.

Education services provided to either available workers or potential employers, it is hypothesized, reduce the time of search or improve the quality of the matches attained. Individuals with more education could be expected to better perceive the requirements of an optimal match and proceed to it with less delay. As a result, the level of search and job-matching costs--essentially, transaction costs--would be reduced because of education. This reduction in costs is a social benefit appropriately attributed to education. It is a direct impact of education and is so depicted in Figure 1. Although some of the resulting cost saving or improved job matches may be captured in increased earnings and, hence, reflected in benefit measures based on wage differentials, it seems likely that most of these effects are not so captured. The true value of education services is, therefore, in excess of that implied by the standard measures.

F. Income Distribution Effects of Education

As has been emphasized, one of the primary impacts of education operates through the creation of human capital, and manifests itself as increases in earnings of individuals who have received education services. These earnings changes are, themselves, reflected in the distribution of earnings and income. Depending on who receives education services and the effect of these services on earnings, the distribution of income can be made more or less unequal because of education. To the

extent there have been compensatory efforts in the provision of education services, individuals with weaker family-background and lower earning capacities have tended to receive education services beyond what they would otherwise have received. By and large, targeted education has been viewed as contributing to a reduction in income inequality.

Individuals have preferences for the degree of inequality existing in the community to which they belong. Stated alternatively, individuals may be willing to pay some positive amount for decreases (or, in some cases, increases) in the degree of income inequality--the degree of inequality is an argument in their utility function. It is this perception that lies at the base of the "optimal redistribution" literature (see Hochman and Rogers, 1969).

If, in fact, the provision of education services decreases inequality and if a reduction in inequality is of benefit to citizens, education services must be credited with this economic well-being benefit as well. In Figure 1, the channel of impact is viewed as running from education services to human capital to earnings effects and then to income distribution effects. This implies that it is only earnings inequality that enters the utility functions of members of the community; in fact, inequality in any dimension of well-being could be relevant. Identifying only one channel, then is an oversimplification.

C. Other Effects of Education

In addition to these channels by which education services generate changes in economic well-being, a variety of other effects of education

have been hypothesized. These other effects will only be mentioned here, and in catalogue form:

1. Education services, it is claimed, reduce the level of external costs which individual behavior imposes on others. Holding all else constant, it is hypothesized that education leads to reductions in criminal activity and delinquency, reductions in accidents causing harm to others or imposing increased health costs on others (e.g., automobile accidents), and increases in community participation and, hence, social cohesion.

2. Education services, it has been suggested, facilitate and further the process of technological advance and the diffusion of new technologies. In effect, the linkages between invention and innovation becomes stronger, making isoquants more elastic and increasing the complementarity between research and development and capital investment.[16]

3. Finally, education has been viewed as a mechanism by which talented individuals can be identified and elevated to crucial positions of leadership. Alfred Marshall (1890), perhaps, expressed this best:

> "We may then conclude that the wisdom of expending public and private funds is not to be measured by its direct fruits alone. It will be profitable as a mere investment to give the masses of the people much greater opportunities to get the start needed for bringing out their latent abilities. And the economic value of one industrial genius is sufficient to cover the expenses of a whole town."

In Figure 1, these effects are shown as stemming directly from education services; in fact, the impacts could be indirect, resulting from changes in any one of the other effects of the provision of education services. Again, standard estimates of the benefits of education based

on earnings differences or the growth accounting framework will fail to capture these benefits of education services.

* * *

This discussion, then, emphasizes the partial nature of the well-being benefits of education estimated from direct returns based on earnings impacts. Several reasons exist for expecting such direct returns impacts to be underestimates of the true well-being effects of education services: 1) the value of leisure, 2) the value of home production, 3) future earnings of children, 4) health effects, 5) fertility effects, 6) consumption effects, 7) labor market search effects, 8) income distribution effects, 9) criminal activity effects, 10) social cohesion effects, and 11) technological diffusion effects. However, other factors suggest that such direct returns estimates yield overestimates of the well-being effects of education. Reductions in mother's home time due to education reduce both leisure and the productivity of home time reflected in children's future earnings. These effects of education--either positive or negative--are not reflected in direct returns estimates. Moreover, earnings impacts may not reflect the aggregate impact of education on productivity if labor markets are in disequilibrium and adjust via changes in unemployment levels rather than wage rates. Intuition, and it is only that, suggests that on balance the former factors far outweigh the latter ones--that the true economic well-being effects are substantially greater than those reflected in direct returns. It is to some of the evidence regarding these former factors that we now turn.

V. Education and Economic Well-Being: Some Evidence on Indirect Channels of Impact

As section IV emphasizes, the contribution of education to economic well-being is much broader than is reflected in increases in market wages or measured economic growth. Education may influence home productivity (particularly efficiency in raising children), health of oneself and one's children (and thus aggregate health status), nutritional intake (which also influences one's own and one's families' health), fertility and contraception (permitting closer attainment of desired family size, amount and type of criminal behavior, and finally the distribution of earnings and income. And evidence exists to suggest that education has such effects and that they are important. This section reviews some of this evidence. It is assumed that the effects described represent the impact of education, holding tastes constant. In this way, the welfare impacts of education can be meaningfully discussed. If, alternatively, education has impacts on these variables by changing individual tastes, the welfare impacts of education are more problematic. In the following sections, we first review the literature on efficiency impacts not reflected in wage or earnings differences; then the contribution of education to economic well-being through altering the income distribution is discussed.

A. Fertility Effects of Education

Education increases the value of a person's time. Since children are relatively time-intensive goods--particularly for women—a rise in the value of a woman's time is likely to lead to a substitution away from

children. One approach used to model this relationship between fertility and women's education has been labelled the "new home economics" (Becker, 1965; Mincer, 1962; Willis, 1973). In this framework, education is related to fertility by later marriage, later child bearing, closer spacing, and more efficient contraceptive use. Hence, education affects fertility through its influence on the value of time, on production function relationships in the home (such as more efficient use of contraceptives and more efficiency in the production of child quality), and on the value of alternative activities and inputs to home production (by altering market income opportunities). For example, as husband's income increases, fertility may increase as more of all goods can be purchased and wife's "opportunity costs" of home time are a relatively smaller percentage of potential family income. Similarly, an increase in wife's education will alter the "opportunity costs" of home time, the value of time spent in the home, and income opportunities.

Empirical work based on this framework generally employs simple reduced form and linear specifications as approximations to estimate the equations of a complex system. The assumption is made that children are relatively intensive with respect to mother's time, but not father's time. This suggests that a partial effect of increased women's education through the increase in the value of her time is a decrease in the demand for quantity of children (or substitution away from children). The increase in potential income resulting from increased education leads to a greater demand for normal goods--including children. The bulk of evidence suggests a net negative association between women's education and fertility (that is, the quantity of children).

Robert Michael (1975), for example, uses the Consumer Anticipation Survey of 1968 and estimates a coefficient of -.06, relating number of children to the years of wife's education. Willis (1973) also finds a negative effect of wife's education, as does Detray (1973) in his analysis stressing the quality of children. However, in a study including wife's opportunity cost in addition to her education, Wolfe (1980) finds opportunity costs have the expected negative sign, but that education itself has a positive sign. This argues that the effect of education on fertility through changing tastes may well be positive. The negative effect through changing opportunities generally dominates, however.

In sum, then, the evidence suggests that education services lead to a reduction in completed family size. To the extent that this represents greater efficiency in achieving desired family size and greater efficiency in producing child services (through child quality), this represents an improvement in well-being.

Additional evidence on the effect of education on fertility is provided in the literature on contraceptive use. If "child services," thought of as the quality adjusted hours of children, are viewed as a consumption good entering parents' utility functions, it follows that securing the optimal amount of child services will maximize utility. In effect, because child services require monetary and time expenditure, parents weigh the benefits of a prospective child to the net expenditure, to obtain their desired family size. If the net value of a conception is negative, the household will improve its well-being by lowering the probability of conception. One way to do this is to use contraceptives. However, contraceptive use involves costs (in terms of expenditures on contraceptives, foregone sexual gratification, or conflicts with reli-

gious beliefs) so that parents may demand more children (use fewer or less efficient contraceptives) than they would if contraception were less costly.

More educated couples may be able to reduce the probability of conception at lower cost than less educated couples. More educated couples may have greater receptivity to new ideas, increased awareness of new techniques, and increased efficiency of use of any contraceptives (Michael, 1975). Several studies (Whelpton, Campbell and Patterson, 1966; Ryder and Westoff, 1971) provide evidence that more educated women have more knowledge of contraceptives and employ more effective techniques. For example, Ryder and Westoff found that more educated couples use oral contraceptives more frequently, are more informed of the timing of the ovulatory cycle, and are more likely to approve of contraceptive use. This, in turn, suggests that education helps families achieve their desired family size--a well-being benefit generally not recognized in the returns to education literature and not measured by observing eduation-related differences in labor market returns.

B. Infant Mortality, Child Health, and Child Quality Effects of Education

As suggested above, child services yield economic well-being, and one component of child services is the quality of children. To the extent that education increases efficiency in producing child quality, well-being is also affected. In the work on fertility and education, child quality and quantity are viewed as substitutes in the household production of child services; education's effect on child quality also influences fertility.

Moreover, because an experience of infant mortality decreases well-being, this is also a channel by which education generates a return not measured in earnings differences. A number of studies have found that education has a positive impact on child survival: mothers with more education are more likely to have a child survive (Wolfe and Behrman, 1981a). Similarly, more educated mothers are less likely to have low birth weight children, which children tend to have a lower health stock (Birch and Gussow, 1970).

Mothers' education also has a positive effect on the height and weight of young children. And, among school age children, mothers' education is also associated a wide set of health measures. Edwards and Grossman (1980), using the Health Examination Survey, a national sample of over 3000 children collected in 1963-65, found mothers' education to be the only socio-economic factor associated with a large set of children's health measures among children 6-11. Measuring health as a latent variable within a simultaneous structural equation model, Wolfe and van der Gaag (1981)[17] also find a significant, though small positive effect of mothers' education on children's health. In another study using the HES data, Edwards and Grossman (1979) find indirect positive effect of mother's education on child quality--intellectual development. The path is from mother's education to improved child's health, which has a positive association with intellectual development.

Increases in parents' education are also likely to affect other dimensions of child quality. For example, another form of increased efficiency in home production is through production of nutrition. In a study of the U.S. (Chernichovsky and Coate, 1979) and another of a developing country (Wolfe and Behrman, 1982), an additional year of a

mother's education is associated with a significant increase in nutrition for each family member, although in a study of Columbia, Heller and Drake (1979) find a more ambiguous effect of education on child nutrition and health.

Father's education is also a determinant of child quality. One early study (Morgan, David, Cohen and Brazer, 1962) found education of the father to be the most important determinant of the education of their children who are heads of households. Children of fathers with more education attain more education and all the benefits that go with it. In a 1971 study, Robert Michael, using the NBER- Census Bureau's Consumer Anticipation Survey of about 4,500 households, found that parents with more education expected a higher education level for their children.

While a good deal of evidence exists that education affects both the number and quality of children, there is little evidence of the effect of child services on either the well-being of parents (whose education level is at issue) or the social benefits of this component of education's effects. A few studies have tried to estimate the total social value of such intergenerational effects. These are limited to first generation types of benefits generally included in the human capital framework--namely, the increments in childrens' earnings attributable to parents' education. A study by Swift and Weisbrod (1965) found that benefits of elementary and secondary education increase by 7 percent when such intergenerational benefits are included. Spiegelman (1968) estimates still larger benefits by measuring both the traditional childrens' earnings benefits discounted back 20 years, and private benefits of the parents attributable to utility increases associated with children's earnings increases, which he estimates as a fraction (.3) of the children's

earnings benefits. Both of these studies indicate that a full estimate of the social benefits of education (including intergenerational effects) is in excess of the private benefits related to market earnings differentials.

Thus, parent's education may influence many aspects of child quality—health, education, achievement, and future market success. Underlying these influences is a hypothesis that education increases the productivity of time spent in home production or at least in "child quality" production. Arleen Liebowitz (1975) has tested the question of whether or not increases in mother's education lead to an increase in home productivity. She assumes that in equilibrium, a woman will equate the value of her home time to her wage rate. As a result, observed differences in home time of women of different education levels with children of varying ages provides a basis for imputing the value of home time. Thus, the essence of her approach is to use the value of a mother's time in the market (her wage rate) to estimate the value of home time, based on the allocation of her time between the market and home.

She observes that for women with small children, education is positively related to both the number of hours of home time and the value of home productivity per hour. As a result, the value of home productivity relative to the market wage is greater for more educated women with small children than those with less education.

The results[18] estimated for 1959 based on the 1/1000 sample of U.S. Census show that college-educated women with a child 3-5 work somewhat less than women with less education (3 weeks less compared to those with a grade school education and 1.8 weeks less than high school educated women). There is a somewhat smaller differential for each child 6-11

present: women with high school and college education work about one week less than those with a grade school education.

This evidence suggests that the increase in market wages resulting from increased education is an underestimate of the increase in women's total productivity attributable to education. When only actual earnings increases are included, women's time spent in child rearing will not be included in the measurement. To fully capture this effect, a full time labor market equivalent value must be adjusted upward to reflect the fact that home time is valued above the market wage for more educated women with young children.

Gronau (1973) also finds that more educated women have a higher shadow-price or value of time with the presence of small children. The presence of a child under 3 was found to increase the value of a woman's time by 30 percent if she is a college graduate.

A final impact of education operating through non-market home production activities concerns the efficiency of the production process for home services. According to Michael (1975), education is like new technology in the home. Households of more educated individuals have more access to knowledge, facts, and ideas and hence are able to act more efficiently. This may also include more efficient market expenditures. This implies that families with more education can do the same home tasks more efficiently, implying that they are better off even if they have the same available time and money as less educated households. Micheal tests this theory by comparing three representative households which vary by income and education[19]. On the basis of this comparison he finds that, ceteris paribus, education improves a family's well-being just as income

improves their well-being. This is interpreted as evidence of an increase in non-market productivity due to increased education.

Thus, there is other evidence that parental schooling, particularly that of the mother, has a widespread positive impact on child quality and these are additional gains from education that are generally not counted in estimates of the benefits of education. Increasing parents' education appears to increase home production in terms of infant and child health, child nutrition, child education (and thereby future market success), and the efficiency of the production process by which home services are produced. And all of these impacts contribute to economic well-being.

C. Own Health Effects of Education

Consistent with a human capital framework, investment in education may be joint with investment in health status. Improved health status is human capital in its own right and, like education, will have some effects which are measured by earning differences, some which are private but not captured in earnings differences, and some which are external to the individual. In recent years, substantial literature on the correlates of health status has appeared; education is often one of the relevant independent variables.

In one of the earliest papers, Michael Grossman (1975) set out a model to explore the effect of schooling on health.[19] Health is treated as a stock (a type of capital) which can be increased through investment and depreciates over time. The stock of health increases available productive time. Education serves to increase the wage rate (and so the

value of productive time); however, education also increases the productivity of time spent on the production of health.

Grossman's estimates, using the NBER-Thorndike data, suggest that each year of schooling increases health by one to three and a half percent (depending on whether poor health was controlled for). Spouse's education also has a positive influence on husband's health and, in fact, the coefficient is larger than husband's own schooling. Finally, using logit analysis, Grossman finds that schooling has a positive and statistically significant effect on the probability of survival. Indeed, it is the single most significant factor among an extensive list of independent variables (including intelligence and income). At the expected mortality rate, a one year increase in education lowered the probability of death by .4 percentage points. Orcutt (1977) has found a similar relationship between education and probability of death.

These findings suggest that education has an important indirect effect on productivity which operates through an individual's own health status. Only to the extent that this form of human capital increment is reflected in market earnings will it be captured in standard estimates of the returns to education. These findings also suggest a positive return from wife's education to spouse's health—an effect likely to be captured in standard benefit estimates only to the extent that own and spouse's education are correlated. And the evidence suggests that education increases the probability of survival. To the extent this is so, a portion of the benefits of education from this source are increased lifetime earnings. For all of these health or survival effects, the willingness to pay of the individual for increased probability of survival, survival past retirement, improved health over one's lifetime are not captured.

Nor are the external effects of improved health or survival effects (for example, spouse's or children's improved health due to an individual's improved health).

D. Crime Effects of Education

The decision to perform a criminal act can be viewed as a utility maximizing response to economic opportunities and, as such, is likely to be affected by education. While education's effect on market wages is well documented, Ehrlich (1975) suggests that education is also likely to increase the productivity of an individual in illegitimate activities, particularly in avoiding detection. Since expected lifetime legitimate earnings are increased through education, the "potential cost" of detection is higher. Hence, individuals with more education are likely to engage in "more profitable" illegitimate activities, if any, and not the most common property crimes.

Ehrlich surveys the limited evidence from a variety of studies to show that those who commit property crimes have relatively low education. However, the evidence is weak since, if his model is correct, criminals with more education are less likely to be detected. The effect of education on illegitimate activities is uncertain.

There is a sprinkling of other evidence: Spiegelman (1968) finds juveniles with more education are less likely to commit crimes; Webb (1977) studied the educational backgrounds of inmates and found many have low education.

E. Income Distribution Effects of Education

As section III emphasized, if people care about the income distribution or income poverty, the effects of education on the income distribution may contribute to or detract from economic well-being. If less inequality is valued, for example, and if education is equalizing, the benefits attributed to education must be supplemented for this reason. Hence, a basic question in measuring the benefits of education is whether education equalizes income or not. Education has been viewed for many years as a means of increasing economic mobility and therefore promoting income equality. However, a number of researchers (e.g., Mincer, 1974; Chiswick, 1974) find that income is more unequally distributed as the result of education and the returns to education. Others (e.g., Marin and Psacharopoulos, 1976; Tingergen, 1975; and Pechman, 1970) conclude that education is an equalizer of the income distribution.

Marin and Psacharopoulos present an insightful way of seeing the source of different findings. Begin with a standard human capital model measuring returns to education,

$$\log Y_s = \log Y_0 + \sum_{j=1}^{S} \log (1 + r_j) + u \qquad (1)$$

and rewrite it is estimatable form

$$\log Y_s = \log Y_0 + rS + u, \qquad (1s)$$

where Y_s = earnings of person with s years of education,

Y_0 = earnings of person with zero schooling,

r = rate of return,

u = error term measuring the effects of omitted variables.

Then by dropping the variance and covariance of u and estimating Var (log Ys) = Var (log rS), one can obtain an estimate of the degree to which income inequality is associated with the current education distribution. In order for researchers to analyze and predict the impact of changes in education (and rates of return) on the income distribution, this equation can be approximated by one which disaggregates the right hand side into its component parts:

$$\text{Var (log } Y_s) = \bar{r}^2 \text{ Var (S)} + \bar{S}^2 \text{ (Var) r} + 2\bar{r}\bar{S} \text{ Cov (r,s)}.$$

As Marin and Psacharopolous point out, some researchers (e.g., Mincer, Chiswick) simplify and assume that r and S are independent random variables. In this case, they estimate var (log Y_s) = $\bar{r}^2$ Var (S) + $\bar{S}^2$ Var (r) + Var (S) Var (r). Since all of these terms on the right hand side are positive, increases in the level of schooling must lead to increases in inequality. If, instead, r and S are allowed to be dependent[20] and, if the covariance of r and S is negative, the income distribution can be made more or less equal through increases in S, depending on the relative size of the positive and negative terms.

Marin and Psacharopoulos perform estimates of the response of the Var (log Y_S) to changes in schooling assuming both independence and dependence. For a close approximation to the level of actual schooling in the U.S., where the rate of return declines as schooling increases[21], they find a one-year increase in schooling of the population leads to a 15 percent increase in income inequality assuming independence and a 10 percent decrease in income inequality assuming the rate of return declines as schooling increases (dependence). This suggests that a good deal of the dispute over the income distributional effects of education stems

from different underlying models or assumptions incorporated into the model, and that at best, the estimates are offering only clues, not clear answers.

Tinbergen uses an alternative model as the basis for his conclusion that education equalizes the income distribution. His model is based on a supply-demand race between technological shifts toward more highly educated labor on the demand side of the labor market and increases in education of the labor force on the supply side. Equalization depends on the relative rate of increase between the percentage of the population educated and the technology-bsed demand for educated workers. Reductions in inequality occur only if the expansion of education overtakes the technology-based demand for higher educated workers. Based on a set of estimates explaining income inequality, he concludes that income inequality could be halved by either doubling the proportion of the population with higher education or increasing secondary school enrollment to 90-95 percent and doubling higher education enrollment.[22]

Dresch also bases his analysis of returns to education and income distribution effects on the technology-based demand for educated workers. In this analysis, the continued high returns to education in the U.S. through the 1970s were a unique period based on technologically based changes and rapid growth of sectors employing highly educated labor. Based on reasonable estimates of substitution elasticities from a model employing fitted production functions, fairly nonrestrictive labor demand models, and a supply model sensitive to demographic and relative wage changes, Dresch estimated that the ratio of college graduate to non-graduate wages would decrease about 13 percent from 1970 to 1990 in response to the relative increase in higher education. This will

equalize the income distribution. As with Tinbergen, Dresch finds that equalization depends on the relative rates of increase of educated persons and the technology-based demand for labor.

Others argue that, in terms of income inequality, schooling appears to have little effect. Even if schooling is targeted at "disadvantaged groups", Jencks (1972), Levin (1971), and Thurow (1972) argue, there will be little change in the inequality of the income distribution. According to Jencks, education alone explains little of the variation in men's incomes. Even if traditionally disadvantaged groups (e.g., nonwhites, women and working class whites) increase their education, their incomes will not increase substantially because of constraints on the access of these persons to highly paid positions. Because most of the financial benefit of education comes via access to more highly paid occupations, increasing or equalizing education for everyone would not equalize incomes since, in his words, "giving everyone more credentials cannot provide everyone with access to the best-paid occupations" (p. 224). Hence, it follows that "equalizing everyone's educational attainment would have virtually no effect on income inequality" (p. 224).

Levin and Thurow also argue that education is not an effective means of equalizing income. Thurow's argument is based on the view that the labor market should be characterized as one of job competition rather than wage competition. The role of education is to determine one's position in the labor queue, while productivity is determined by on-the-job training after one's position is attained. Since education only affects one's position, not productivity, educating an additional person leads to equalizing within an education group, but may accentuate the differences between groups.

An important question in evaluating the contribution of education to well-being via its impact on income inequality or poverty concerns the distribution of education services. Clearly, the distributional impact will be different if educational services are targeted on the disadvantaged population as opposed to, say, being distributed equally. One common view is that the public-private financing of higher levels of education has a regressive effect on the income distribution insofar as the children of upper socioeconomic groups have a greater probability of attending college than children from less well-to-do parents. An alternative view is that public subsidies or loan programs allow lower-income children to attend institutions of higher education. This increase in socioeconomic mobility reduces income inequality and this should be included in any measure of social benefits.

The evidence on the mobility effect is that there is some limited response to subsidies, but the elasticity is low (approximately .3). (See R. Freeman, 1969.) Even if all individuals who attend colleges only if they receive subsidization are from low income families, Freeman argues that 75% of the subsidies are allocated to students from higher income families.

Rivlin (1975) has also addressed the question of the distributional effects of targeted education programs. In her view, even such targeting efforts will not substantially reduce income inequality: only a limited number of the poor receive such subsidization, education does not have large income impacts and these income impacts only are realized over the long run, and the relative earnings of educated workers have begun to erode.

From this brief survey, then, it seems clear that the evidence on the effect of education on the income distribution is not conclusive. This is due to several factors: data limitations, the lack of clarity on the way the demand for educated labor interacts with the supply of educated labor, the existence of a dependent relationship between the returns to education and the quantity of education, and the distribution of additional education services. However, all of these studies only include the earned income effects of education in measuring the income distribution effects. The effect of education on the distribution of nonearned income or a more comprehensive definition of full income including the value of leisure time has not been analyzed. As a result, the influence of education on inequality in distribution of well-being is likely to be understated. In any case, it seems quite impossible at this stage of understanding to attribute any social well-being benefits to education operating through the income distribution effects. Neither the social benefits of reduced inequality nor the equalizing effects of educational services are known with confidence.

* * *

In sum, then, the indirect effects of education on economic well-being which we have discussed point to the following conclusion. Education tends to reduce completed family size. This is partly explained by the increased ability to achieve desired family size through more efficient contraceptive use. In addition, education leads to more efficiency in producing higher quality children, in part through improved nutrition. Since the utility from children (according to the new home economics) comes from child services, quality, more education leads to

more quality, which leads to a reduction in the quantity desired. Education improves several dimensions of child quality: child health, intellectual development, education, and expected income. Including education and expected income benefits may increase the measured returns to education by one-third. Education also leads to greater efficiency in consumption. Thus, more education indirectly leads to greater utility through improved market expenditures. Still further, education improves own health, spouse's health, and decreases expected mortality. To the extent these are beyond wage increases, they are not captured in standard estimates of the benefits of education. There is also some evidence that crime may be reduced due to increased education. Finally, evidence was presented on the effect of education on the income distribution. The overall effect is not clear, although education has played a role and targeted education policies, or large increases in the college educated, may decrease income inequality.

Evidence on other effects of education such as social cohesion, leadership, the speed of technological diffusion, are not discussed. The first are not included because there is little documentation of these effects, the latter because another paper in this series deals specifically with this issue.

VI. Implications for Research and Policy

Our discussion suggests that the provision of education services is likely to have a larger impact on economic well-being than is estimated by studies based upon either the direct returns or growth accounting frameworks. The primary effects which contribute to this overall impact and

which are not reflected in the standard studies include health and longevity related effects, fertility and child quality effects, income distribution effects, and social cohesion effects. The conclusion that standard estimates understate the total effect of education services reflects the judgment that the overstatement of the well-being effects of education in the standard estimates (due to erroneous estimates of the value of the home time of spouses and the displacement effects emphasized in disequilibrium models) is exceeded by the health, fertility, home productivity, social cohesion, and distributional effects of education on well-being which are not measured in the standard estimates).

This conclusion suggests that the total contribution of education to social well-being is in excess of that reported in the standard rate of return to education estimates. It does not, by itself, lead to any policy conclusion regarding the level of public support for education. The question of public support must rest on an appraisal of the public good component of total educational benefits, externalities associated with the provision of education services, or other market failures restricting the ability of the private sector to optimally respond to the demands of individuals reflecting the private goods benefits of education. The preceding discussion does not directly address this question. Nor does this discussion shed very much light on the optimal composition of resources allocated by educational services. The internal rate of return on marginal expenditures in various directions is required for judgments on this issue.

There are some policy-related conclusions which this discussion suggests, however. First, if those components of economic well-being generated by education services but not captured in the standard estima-

tes (e.g., health and nutrition benefits) are private goods, private decisions will reflect them automatically, with no implication for public support.[23] This is so, of course, unless market failures (e.g., private capital market failures) restrict the ability of individuals to secure the desired level of education services privately. Many of the non-human capital benefits we have identified have this private good character--a large share of health and nutrition benefits, fertility benefits, and job search benefits are of this sort. Others, however, are dominated by externality or public good traits. These include the income distribution effects, the social cohesion and technology effects, and some share of the health and fertility effects. To the extent that these channels of benefit comprise a larger share of total benefits than is commonly believed--and our review of the evidence does suggest major well-being effects through these channels--increases in public support toward education would be justified.

Second, to the extent that these less recognized channels of well-being effects are public good or externality dominated (or if private good in character, but constrained due to market imperfections), the allocation of resources within the education sector should emphasize these outputs. This implies that educational services which induce behavioral change related to fertility, health status, or labor market search or which secure desirable changes in the inequality of income (e.g., compensatory education) should be emphasized.

A third conclusion relates more to research than to policy. If education services create public, unmarketed benefits as well as private benefits, a special burden is placed on empirical work designed to measure the full willingness to pay for education services. The problem

is not unlike that which dominates the question of the economic well-being effects of environmental improvement. Like education, environmental improvements convey economic well-being through a variety of channels--health effects, amenity affects, materials damage and cleaning effects, and expansions of recreational options.

One question then, is: Does research in the environmental area designed to measure the benefits of environmental improvement have any lessons for the education area? One important line of environmental research is designed to measure the public good benefits of environmental improvements. This research rests on an extension of the hedonic technique. When applied to property value or wage differences, this indirect non-market evaluation technique is able to estimate the contribution of environmental services (or other public goods) to these observed price differences and, under certain conditions, to translate this contribution into the willingess to pay (economic benefits) of changes in environmental quality.

Because non-marketed environmental effects result in alterations of decisions regarding the purchase of private goods, the observed prices and outputs of private marketed goods can be used to infer benefits from public environmental outputs.

Some, but clearly not all, of the benefits of education services have public good characteristics similar to those of environmental services. Such benefits (for example, social cohesion effects and those effects which induce "desirable" behavioral traits on the part of those who are educated) are experienced by those who come into contact with people who are "educated." One could claim, then, that in the same way that neighborhoods with less air pollution are, ceteris paribus, more desirable

than neighborhoods with more air pollution, so too will neighborhoods with a higher proportion of "educated" people be more desirable, ceteris paribus, than neighborhoods with a lower proportion of educated people. And in the same way that hedonic procedures are able to measure the public good-type air quality benefits associated with individual pieces of property (or particular jobs, through wage differentials), such procedures could, in principle, be used to estimate some of the public good benefits of educational services[24]

Implementation of this research approach, however, requires that several questions of a conceptual or theoretical sort be answered prior to estimation. These include: 1) What are the components of the public benefits of educational services which have the site specific (or job specific) requirements necessary for such hedonic based estimation techniques.[25] 2) What conditions regarding factor mobility, the efficiency of private market operation, and the perception of the benefits of education must hold for these public benefits to be accurately reflected in price and output observations in property and labor markets. In addition to these conceptual issues, a crucial empirical issue must be confronted: Do data exist to allow the effect of "associating with educated people" on observed prices in property or labor markets to be distinguished from the wide variety of other determinants of such prices? These determinants (in the property market case) range from detailed housing characteristics, environmental and amenity characteristics of neighborhoods, the proximity of neighborhoods to employment and shopping centers and to mass transit facilities, the socioeconomic and racial characteristics of neighborhoods, and the school quality and income level of neighborhoods. This last determinant poses especially difficult

problems as the possibility of statistically separating it from the education level of residents in a neighborhood is not clear.

A second approach would also appear to hold some promise for measuring the willingness to pay for the private non-market benefits of education. If the alternative ways of producing each benefit can be identified, and their costs measured, the least costly of the alternatives can be used as a measure of willingness to pay. In order to do this, a production function for the benefit can be estimated using all inputs (including education) as determinants of output. This could build on the production function work done for firms using a general form such as a translog production function which allows for substitute and complementary relationships among inputs. Through this approach, the value of a one year increment in education in terms of the increase in a particular benefit (output) can be estimated. Alternative ways to obtain the same increment to output can also be obtained from this production function, and the "cost" of these alternatives can be derived. Using this information, the least costly alternative can be identified and its value employed as a measure of the willingness to pay. This approach rests on the "alternative cost" basis of benefit estimation, and requires the assumptions which make this basis equivalent to willingness to pay.

For example, consider the child health benefits of education. Parents' education, prior medical care, and family income could be included in the production function of this variable, while controlling for infant birth weight, any hereditary health conditions, child age, and sex. The coefficient on parents' education would measure the increase in child health due to a one year increase in parents' education. The estimate would also indicate how much medical care and sepa-

rately how much family income would be necessary to produce an equivalent gain in child health. The family income estimate would be a direct dollar value; that for medical care would have to be estimated. The lower of these dollar value equivalents could then be taken as the willingness to pay for each additional year of education in terms of the private child health benefits.

For the estimates from such an approach to be reliable, all inputs into child health (or any other benefit) would have to be included in the estimate, for omitted variables may yield biased results. Nevertheless, this approach may provide a means of deriving estimates for a broad set of non-market private benefits.

Both of these approaches, then, have problems. These notwithstanding, we would suggest their potential viability for quantifying important components of the total benefits of education components which have thusfar been discussed only in qualitative and speculative terms.

FOOTNOTES

[1]Among the important pioneering works in the human capital literature are Becker (1964), Mincer (1958), and Mincer (1970). See Rosen (1977) for a good survey of the empirical human capital literature. Denison (1962, 1967 and 1979) is the founder of and major contributor to the growth accounting approach.

[2]One could claim that, by not choosing private schools, the parents of public school children are also making a private choice regarding the quantity of education services to be provided to their children. However, because public education services are provided at a zero price, the notion that an effective private choice has been made appears to stretch the meaning of that term.

[3]The notion of private benefits in the case of elementary and secondary education is not straightforward. Clearly some of the benefit is expropriated by the student him or herself and will be reflected in labor market earnings or consumption benefits, as in the case of higher education. In this case, however, some private benefits will be received by the parents of the student. We will label both as private sources of benefit.

[4]This definition of willingness to pay is that of the compensating variation--the amount the individual would have to be compensated to maintain utility constant in the case of, say, an increase in the price of a good or service, evaluated at the new set of relative prices.

[5]This concept of well-being effects rests on the same theoretical basis as the concept of benefits in benefit-cost analysis. (See Haveman and Weisbrod, 1975.)

[6]Most of this research has focused on the benefits of changes in air and water quality; changes which are by their nature public goods. A review and critique of this research is found in Freeman (1979).

[7]This conclusion is based on the assumption that aggregate willingness to pay is the summation of that of the individuals benefited by the good or service--that there are no weights other than unity attached to any individual benefits. This is a standard assumption (see Harberger, 1971a).

[8]Education is also likely to affect non-monetary differences among jobs--differences in the dirtiness, difficulty, and unpleasantness of jobs. The willingness to pay for these job quality differences should, like leisure differences, be reflected in the aggregate benefits of education.

[9]It has also been speculated that, because the quality of the home time of mothers "induced" into the labor market by own education may increase, the overall effect of mother's education on the achievement level of children may not decrease.

[10]Both adjusted and unadjusted estimates of the benefits (private returns) of education are presented in the literature. Unadjusted estimates are found in Psacharopolous (1977) and Behrman, Wolfe and Tunali (1981) make rate of return estimates based on the shadow price adjustment.

[11]A stylized model of this form can be represented by:

1) $U = U(N, Q, Z)$ where N, Q and Z represent the number of children, child quality, and non-child sources of satisfaction. Q and Z are produced in the home according to production functions

$Q = f(T_c/N, X_c/N)$ where T_c = time spent on children,

X_c = market goods allocated to children

$Z = g(T_Z, X_Z)$, where T_Z = time spent on Z,

X_Z = market goods allocated to Z.

Under certain assumptions (e.g., linear homogeneous production), child services (C) is a function of average child quality:

$C = NQ = f(T_c, X_c)$.

There is a time and income constraint: in full income terms

$I = \Pi_c NQ + \Pi_Z Z = \Pi_c C + \Pi_Z Z$ where Π_i are shadow prices of C and Z, respectively.

[12]Figure 1, however, does suggest that education induced changes in fertility may affect productivity by affecting earnings and the quantity or quality of home time spent with children.

[13]Increases in health status might also increase the value of home production and leisure time and, through them, the value of "home time" provided to children. These are ignored in the diagram.

[14]The correct basis for measuring the well-being effects of increases in longevity is also the willingness to pay concept. Its use in evaluating the benefits of increases in longevity and well-time, irrespective of the source of the increase, is analyzed in Mishan (1971). Note that to the extent that health care costs are not individually borne, the benefits of improved health status in the form of reductions in health care costs are not reflected in private willingness to pay. This component then must be estimated independently and added to willingness-to-pay benefits.

[15]The sign on these effects is not unambiguously positive, however. While education may well increase the value of certain types of consumption (e.g., music), it is likely to decrease the value of other consumption forms (e.g., stock car races). Therefore, from society's point of view, the net well-being impact of education through this complementary consumption effect depends on the utility function of the evaluators.

[16]As R. Nelson (1978, p. 467) stated: "The production and installation of new technology requires educated workers; further, in the absence of technological advance educated workers would be doing nothing different than uneducated workers and would not be more productive."

[17]In Wolfe and van der Gaag, overall health status is specified as a function of various socioeconomic variables. The model has the following form:

$$H^* = \alpha x + \varepsilon_1 \tag{1}$$

$$HC_i = \beta'_{1i} z + \beta'_{2i} H^* + \varepsilon_{2i} \qquad i = 1, 4 \tag{2}$$

$$N_j = \gamma_j H^* + \varepsilon_{3j} \qquad j = 1, 7 \tag{3}$$

where H^* represents the latent variable health status, X is a vector of exogenous variables, HC represents health care utilization, N_j represents need (or health proxy variables), β's are parameters estimated and the ε's are disturbance terms assumed to be normally distributed and independent across equations.

[18]The equations estimated by education subgroups of women are of the form:

$$LFP = a + b\ (\text{wage}) + c\ (\text{children by age groups}) + \gamma X,$$

where LFP is measured in weeks and the X vector includes other factors likely to affect LFP.

[19]1 has more income than other 2; 2 more education but same income as 3, and 3 the same education as 1 and same income as 2.

[19]The model is:

$$H_{t+1} - H_t = I_t - \delta_t H_t$$

then

$$\ln I_t = \alpha \ln M_t + (1 - \alpha)\ln T_t + pE$$

is the gross investment of production function, and the reduced form demand function is

$$\ln H_t = \alpha\varepsilon \ln W_t - \alpha\varepsilon \ln P_t + p\varepsilon E - \delta\varepsilon t - \varepsilon \ln \delta_1$$

where H_t = health stock at age t,

I_t = gross investment and δ_t is the rate of depreciation,

M_t = vector of market goods used to produce I of health,

T_t = person's own time input and E = education,

p = percentage improvement in nonmarket activity due to E,

P_t = price of M_t,

ε = elasticity,

α = parameters estimated.

[20]Dependency of r and S will exist if (1) r depends on the level of schooling, or (2) those expecting higher rates of return (r) select more schooling. Both of these seem quite likely, and are consistent with research in the area.

[21]They perform this estimation using a parameter derived from the quadratic formulation of Mincer.

[22]The estimates are based on national data of developed countries.

[23]This might, however, explain the disparity between declining measured rates of return to higher education and continued high demand for higher education.

[24]Freeman (1979) contains the most extensive discussion of the use of this technique to measure environmental benefits.

[25]In fact, it is not at all clear that such public good effects of education services comprise more than a trivial share of <u>total</u> education benefits or a major proportion of the public good benefits of education services. For example, the income distributional effects of education, while public good in nature, are not likely to be site specific.

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